

2023 BETO Peer Review

Systems Development & Integration Overview

Jim Spaeth, Program Manager

April 3, 2023



Feedstock



Algae



Conversion



Systems



Data



Systems Development & Integration Overview

- **The Team**
- **Program Goals**
- **Challenges**
- **Budget**
- **Key Strategy**
- **Program Results**
- **SDI Response to 2021 Peer Review**
- **2023 Peer Reviewer**

The SDI Team



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Program Manager



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Technology Manager



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Technology Manager



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Frank Fields
Project Monitor



Anthony Sorbera
Project Monitor

BETO Mission & Goals: Decarbonize Transportation

Strategic Goal

Decarbonize the sector through R&D to produce cost effective sustainable aviation and other strategic fuels.



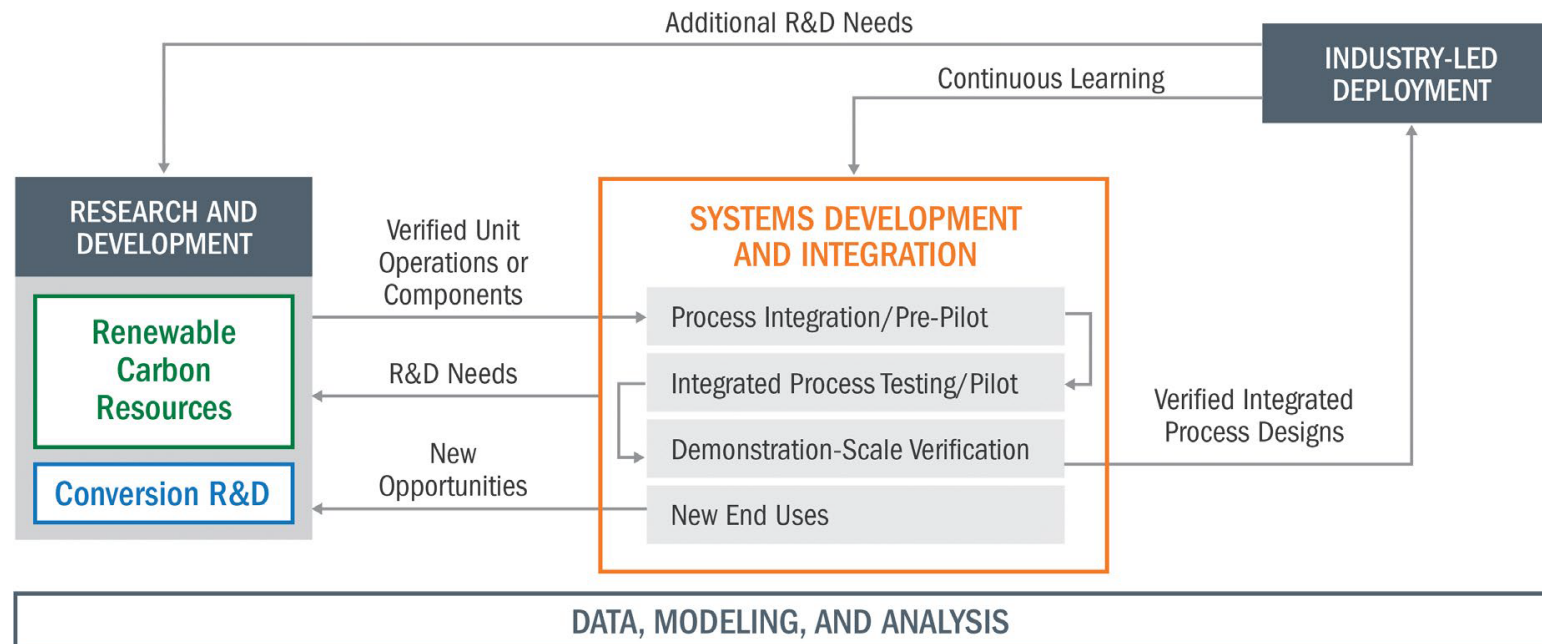
2030 Performance Goal

- Support scale up of at least four demonstration-scale integrated biorefineries with a focus on SAF capable of >70% GHG reduction.
- Support efforts to produce 3 billion gallons of domestic SAF production and use.

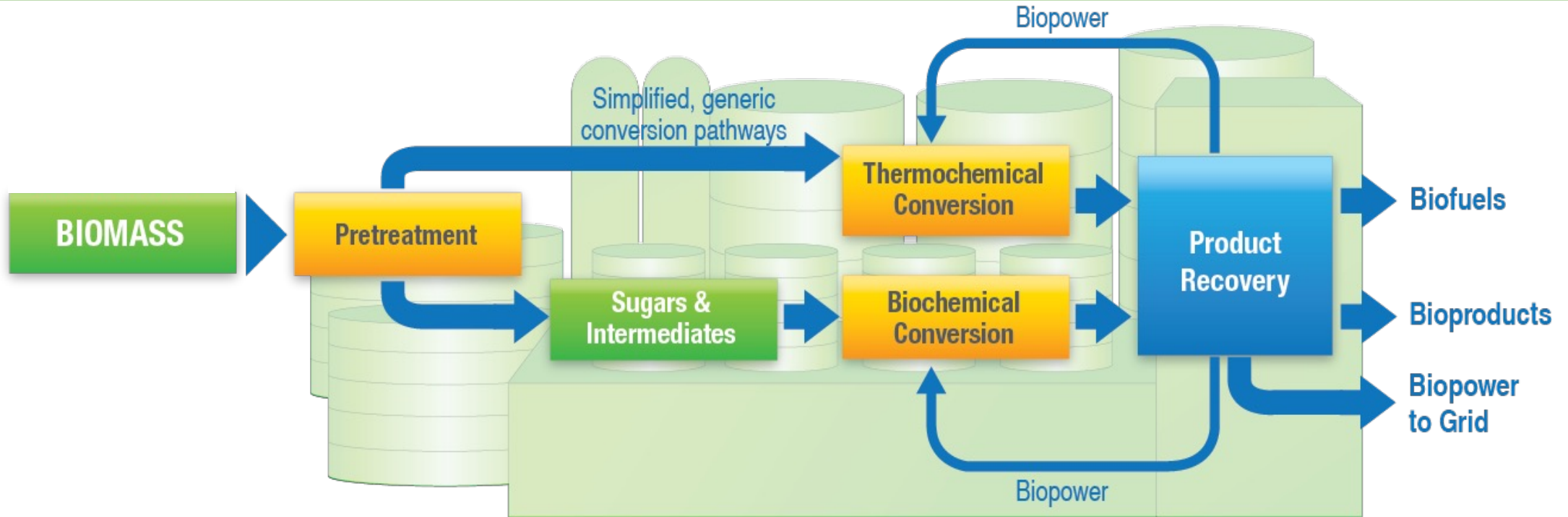
System Development & Integration Goals

SDI Strategic Goal

- Develop and test bioenergy production technologies through verified proof of performance at pre-pilot-, pilot-, and demonstration-scale systems in relevant environments;
- Research methods and tools to enhance scaling and integration to de-risk bioenergy production processes; and
- Accelerate the uptake and commercialization of these technologies by the private sector.



SDI – System Wide Integration Challenges

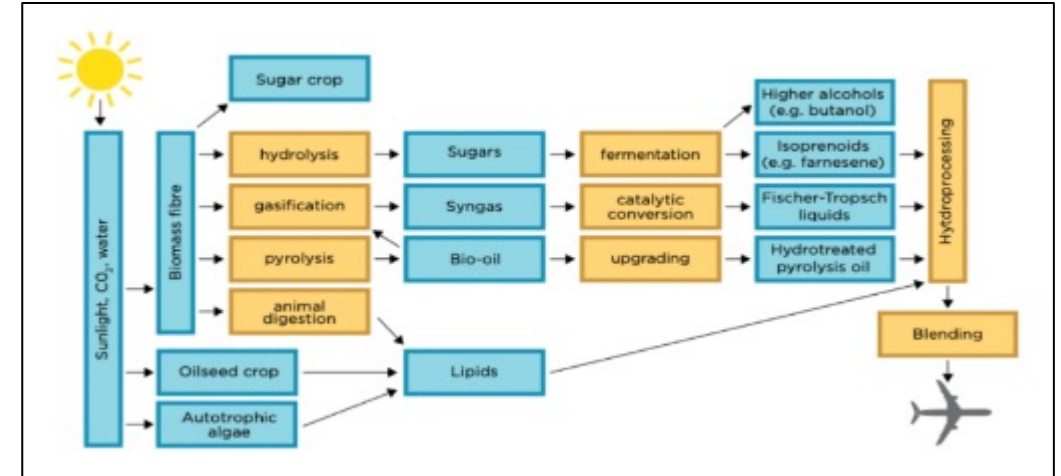


Key Challenges

Feedstock	Pretreatment	Conversion	Product
<ul style="list-style-type: none"> Reliable supply Consistent quality Affordable delivery 	<ul style="list-style-type: none"> Biomass feeding, sizing and moisture Solids handling Material of construction 	<ul style="list-style-type: none"> Products yields Material of construction Catalysts Fermentation organisms 	<ul style="list-style-type: none"> Separations Catalytic upgrading Recycle loops

DOE Technology SAF Scale-up Strategy

- Annual Opportunities for pre-pilot, pilot, and demonstration scale projects
- Wide variety of feedstocks
 - Traditional cellulosic feedstocks
 - MSW, CO₂, CO, flue gas, and biogas
 - Corn starch and oilseeds
- Allow bioproduct opportunities
- Leveraging existing industrial infrastructure supply chains
 - 1st Generation ethanol, pulp and paper, petroleum refineries
- Predictive models and high-performance computing



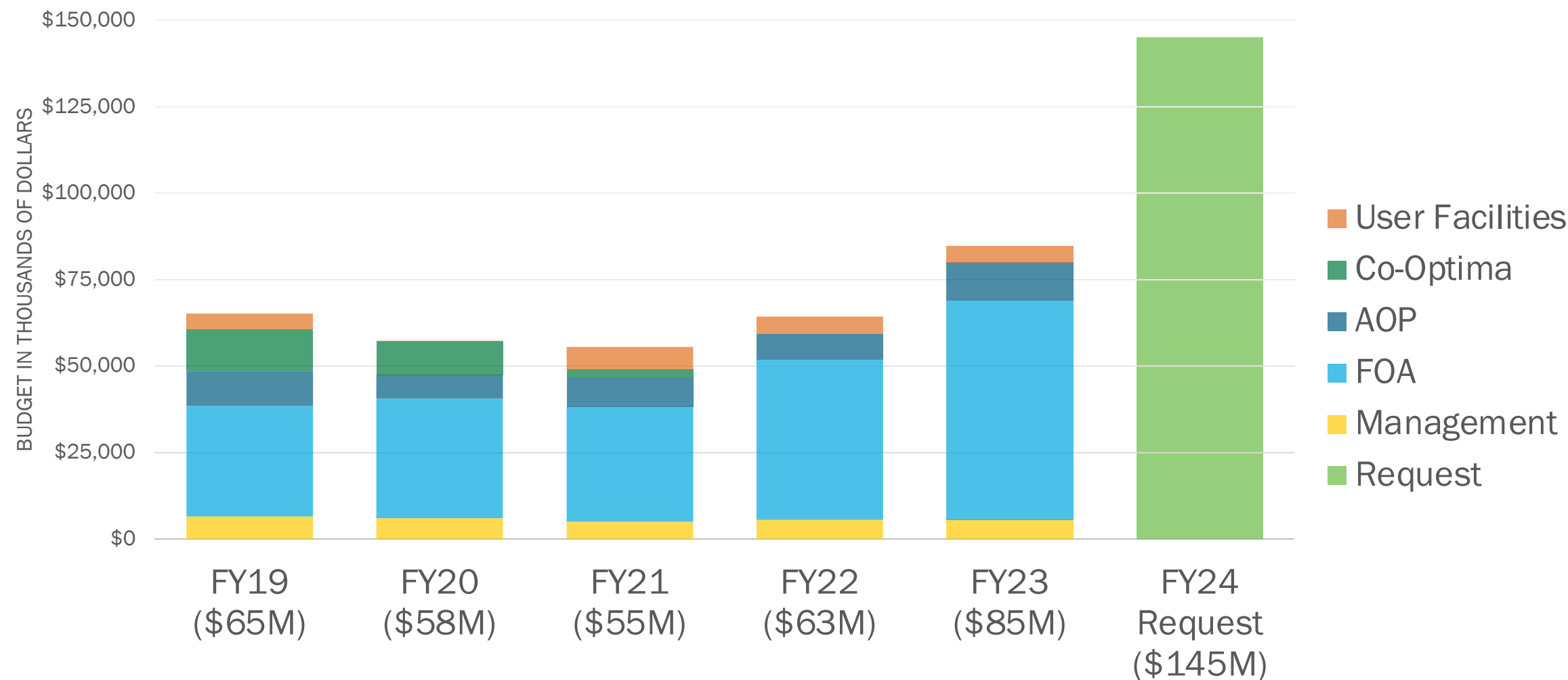
SDI FY23 Program Priorities

- **Complete FY22/FY23 SDI FOA Awards**
- **Complete the down-select of at least one project from the FY21 SDI FOA**
- **Grand Challenge Roadmap – Building Supply Chains**
 - Regional coalition development
 - Technology demonstration
 - SAF Modeling
 - Financial community engagement
- **Marine Fuels Development**
- **Rail Strategy into Off Road Transportation Plan**
- **International Efforts**
 - Biofuture Clean Energy Ministerial Initiative
 - Mission Innovation Zero Emission Shipping
 - Sustainability Aviation



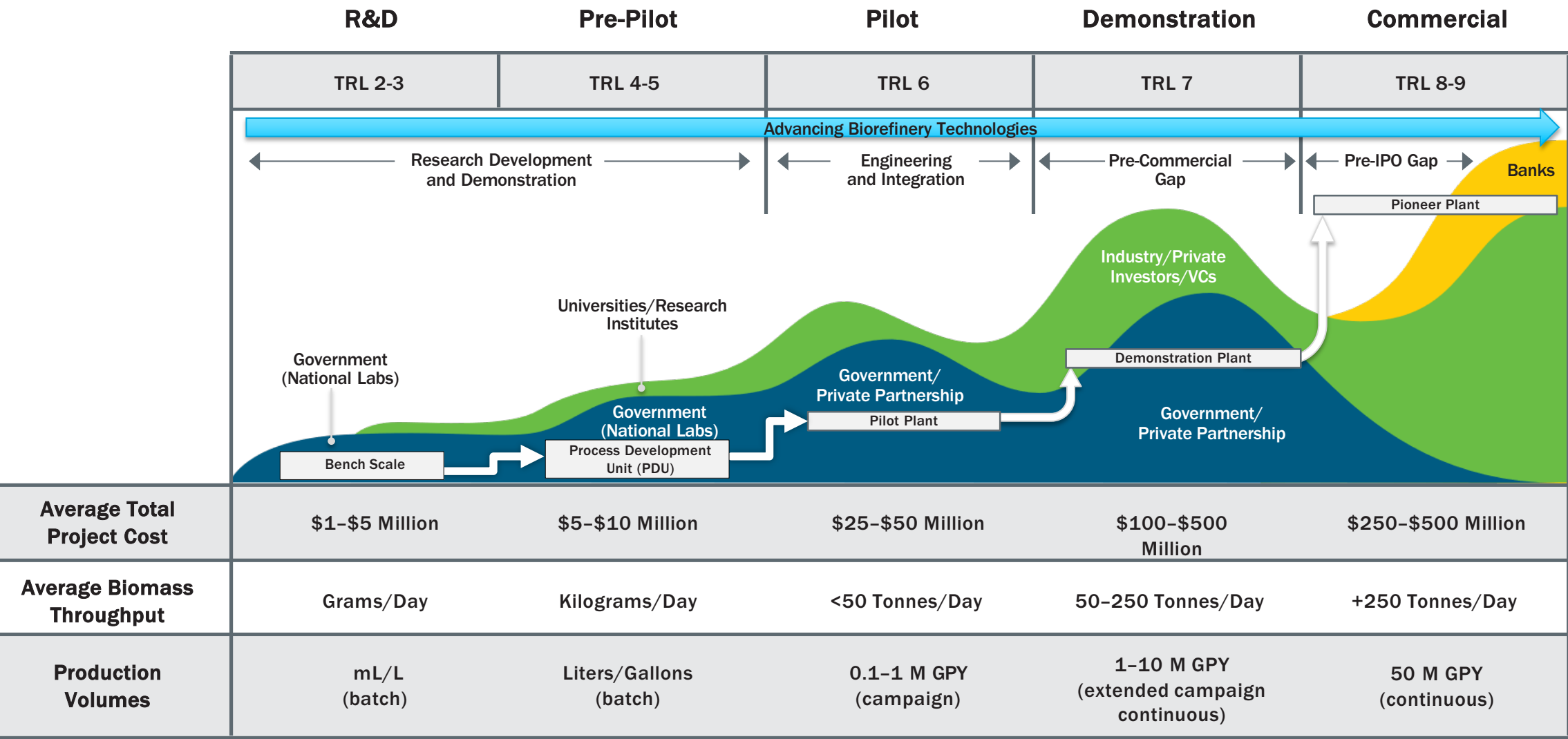
SDI Budgets - FY 19-24

SDI FUNDING BY CATEGORY

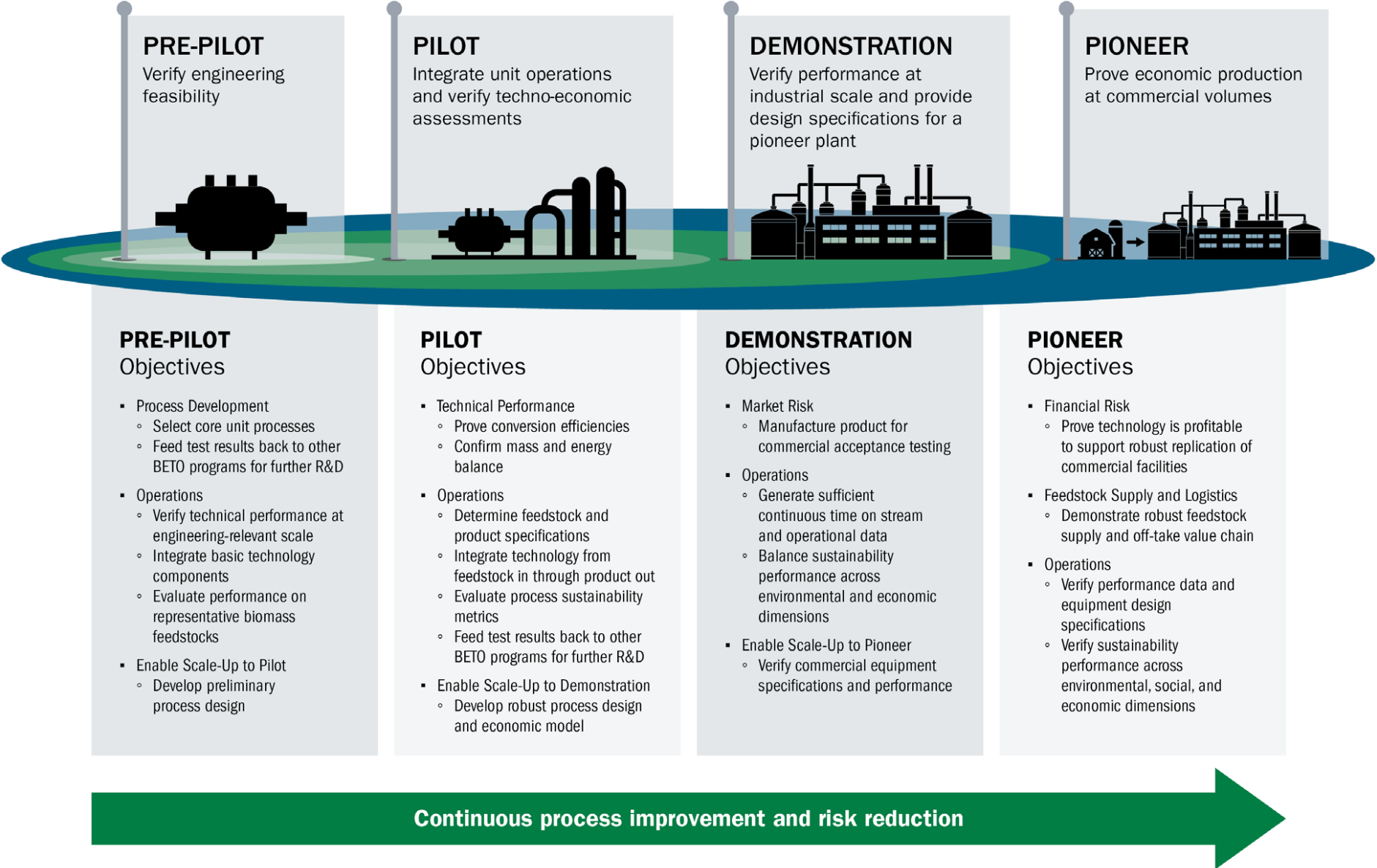


Note: \$46 million of FY22 FOA funds carried over into FY23

SDI Scaling Strategy – Pre-Pilot to Demonstration prior to Commercialization



Scaling Objectives from Pre-Pilot through Pioneer Scale



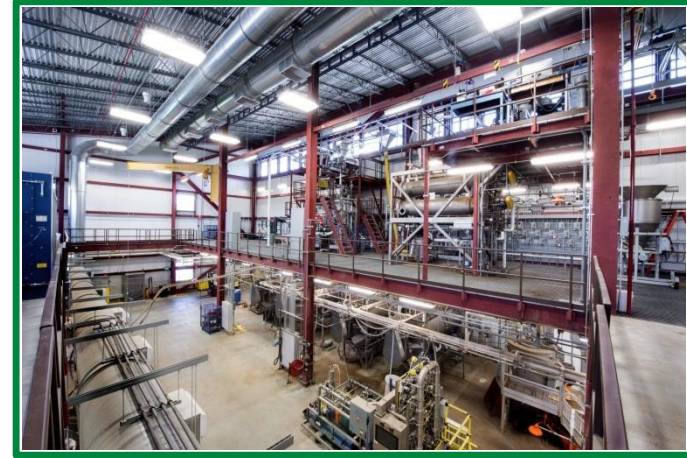
National Laboratories Process Development Units



Advanced Biofuels PDU
LBNL



Biomass Feedstock PDU
INL



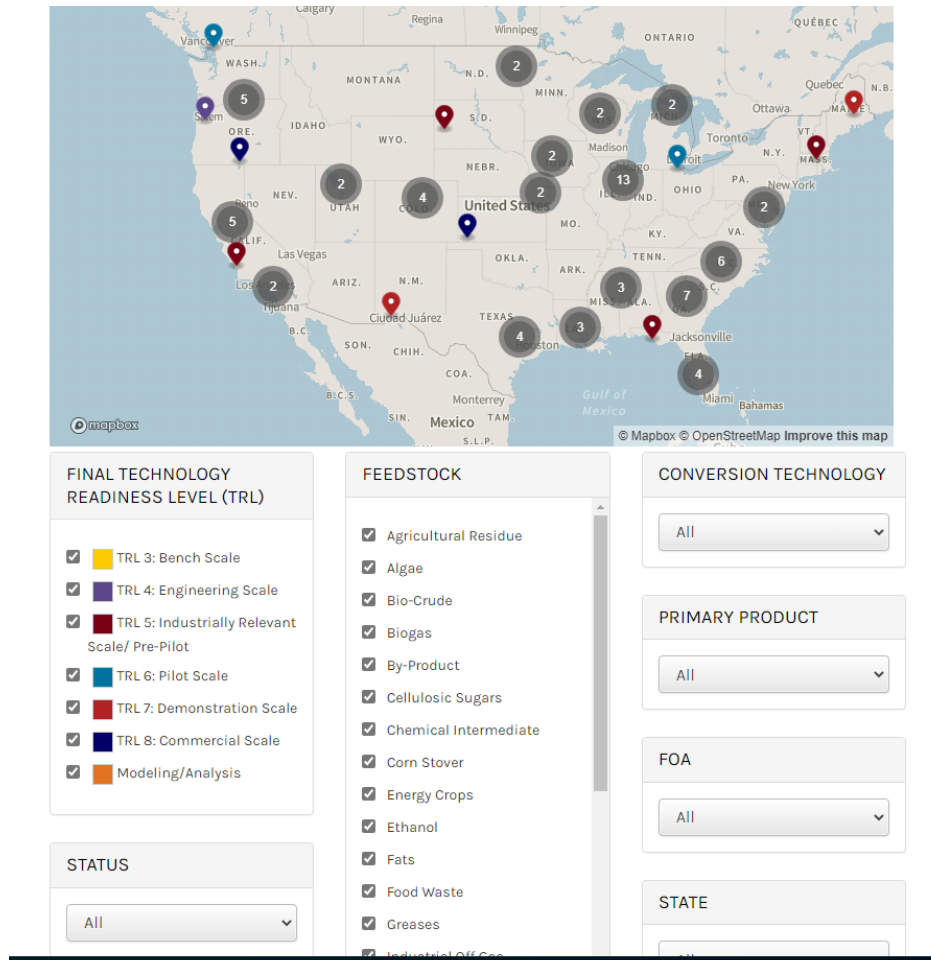
Integrated Biorefinery PDU
NREL

Coupled
Pyrolyzer -
DCR
NREL



Hydrothermal
&
Hydrotreating
PDU
PNNL

SDI Program FOA History – Project Website

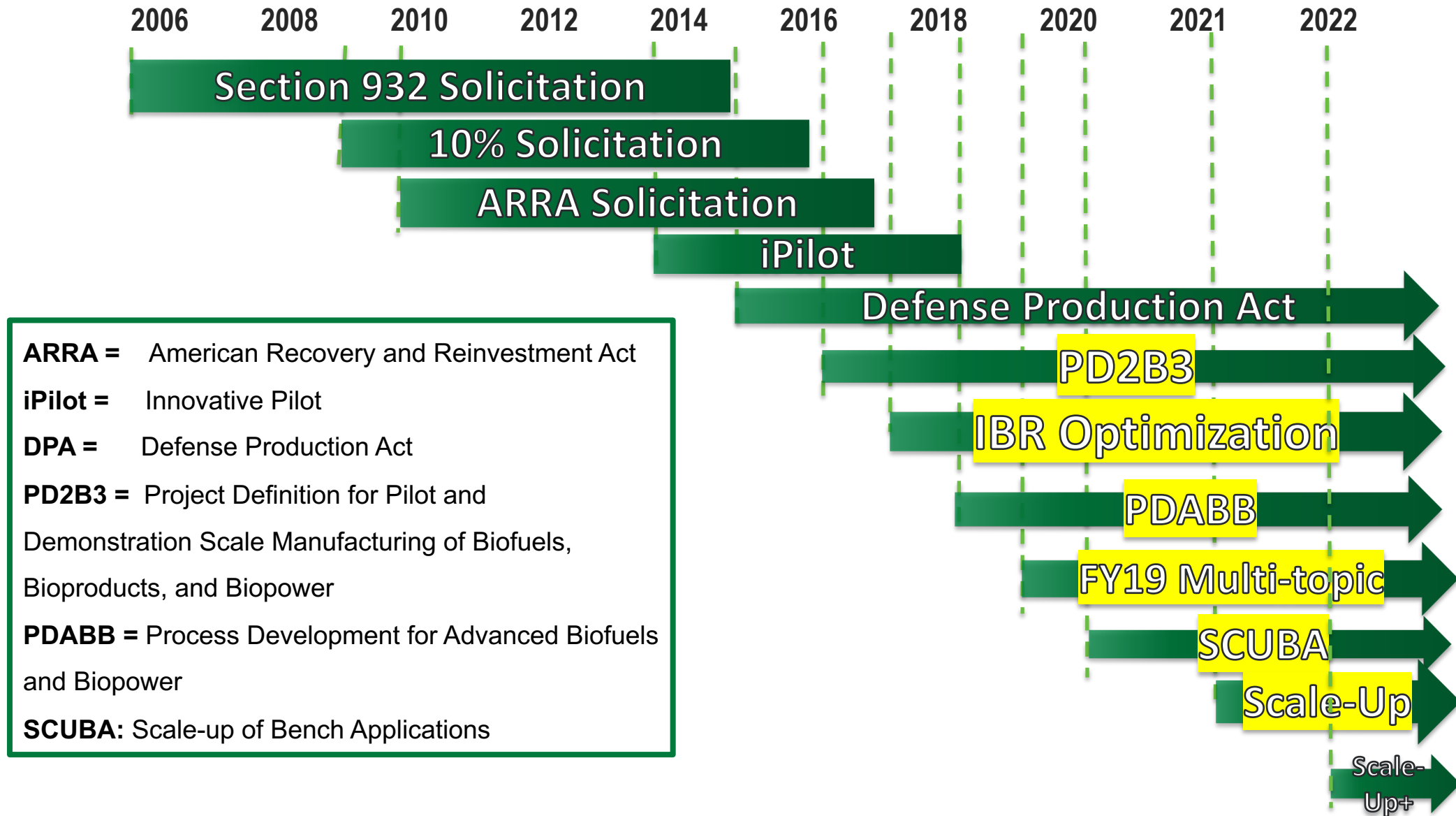


Final
Technical
Reports

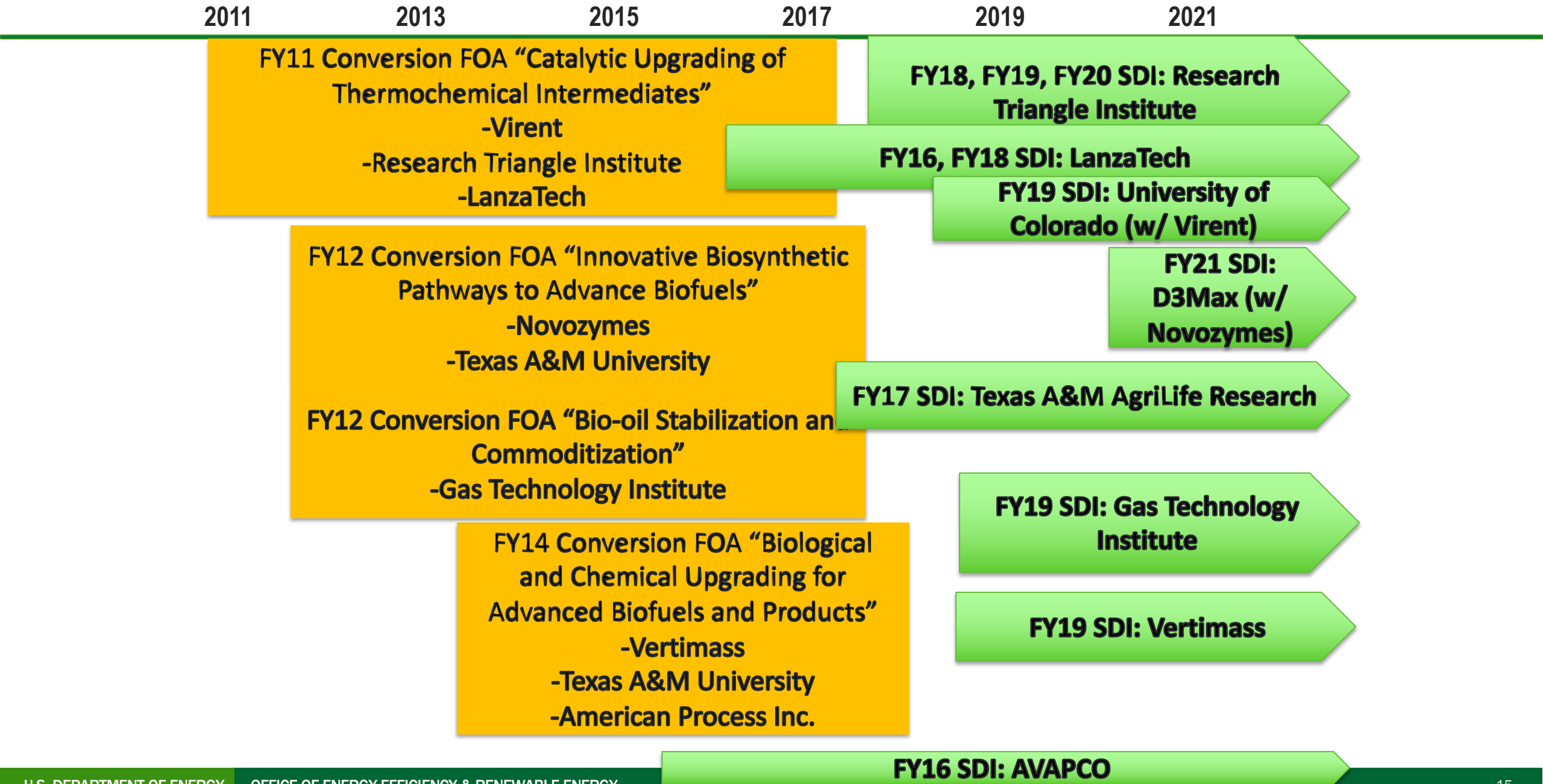


<https://www.energy.gov/eere/bioenergy/integrated-biorefineries>

SDI Program FOA History



Former Conversion FOA projects – Evolved into SDI Awards



DOE Awards \$118 Million to Accelerate Domestic Biofuel Production

- 17 projects will boost production of biofuels for consumer and freight transportation in America, support President Biden's decarbonization and climate agenda
- Pre-pilot, pilot, and demonstration projects
- Award amounts range from \$500,000 to \$80 million.
- Align with renewable fuels goals in the first-ever [U.S. National Blueprint for Transportation Decarbonization](#), a multi-agency framework for reducing emissions, creating a robust transportation workforce, and securing America's energy independence.



FY23 Pilot and Demonstration Projects

Project	Location	Conversion Technology	Scale	Feedstock	Award
Lanzatech, Inc.	Skokie, IL	Gasification—Gas Fermentation	Pilot	Woody Biomass	Phase 1 Negotiation \$1,640,286
Microbio Engineering	San Luis Obispo, CA	Hydrothermal Liquefaction	Pilot	Waste Water Solids	Phase 1 Negotiation \$579,673
Alder Fuels, LLC	Southeastern US TBD	Fast Pyrolysis	Demo	Woody Biomass	Phase 1 Negotiation \$2,000,000
AVAPCO, LLC	Thomaston, GA	Alcohol-to-Jet	Demo	Woody Biomass	Phase 2 Negotiation \$80,000,000



AVAPCO - From Strain Development to Demonstration

The project partners have invested more than 10 years in the development of low carbon footprint **cellulosic SAF** and **renewable diesel** along with **high-value co-products**.

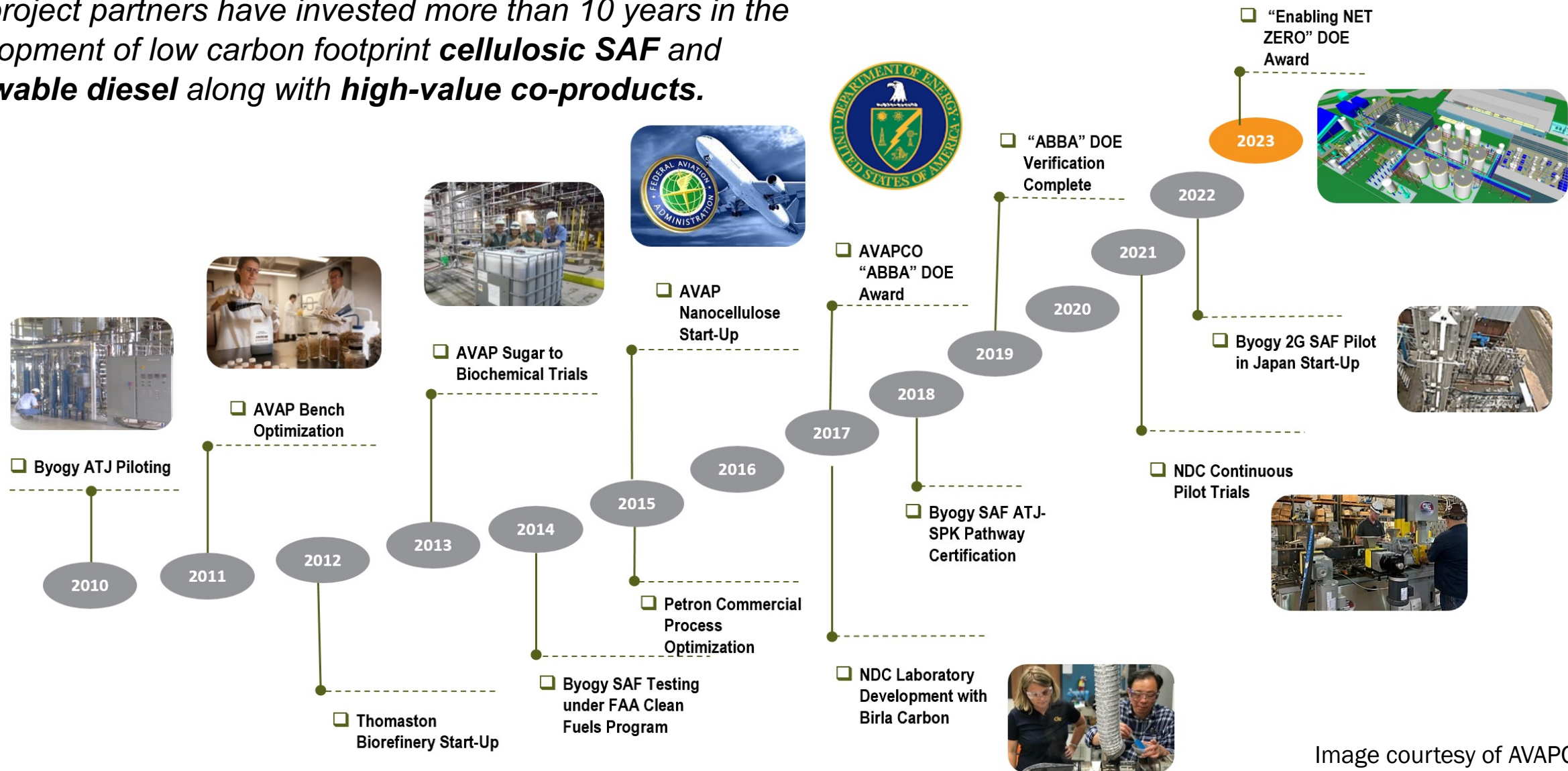


Image courtesy of AVAPCO

FY21 Scale-Up FOA Project Selections

	Selectee	Feedstock(s)	Conversion Technology	Product	Fuel Opportunity Size (billion gal/year)
Pre-pilot	MicroBio Engineering Inc.	WWT Sludge	HTL	- SAF - Fertilizer (Focus)	8.3
	Alder Energy	Miscanthus	Advanced pyrolysis oil fractionization Test flight at end of project	- SAF	8.8
	Gas Technology Institute #1	AD Biogas & Waste CO2	Electric Reformer & Gasification	- SAF - Diesel	2.6 to 12.6
	Gas Technology Institute #2	MSW & 3 cellulosic feeds	Feed system & Gasification	- SAF	3.3 to 8.8
	Texas A&M AgriLife Research	Corn Stover	Fermentation	- PHA (Focus) - SAF	7.2
	University of Maryland: College Park	WWT Sludge	HTL (with supercritical CO2)	- SAF - Diesel	8.3
	LanzaTech, Inc.	Waste CO2	Gas Fermentation	- SAF - Diesel	4.6
	Global Algae Innovations	CO2 (direct air capture)	Algae	- SAF	5.6
Pilot	D3MAX, LLC	Corn Stover	Fermentation	- SAF	7.2
Demo	T2C-Energy	Landfill Gas	Gas to Liquids	- Diesel	6.4
	SkyNRG Americas, Inc	Landfill Gas	Gas to Liquids	- SAF	1.6

FY22 Scale-Up FOA Project Selections

	Selectee	Feedstock(s)	Conversion Technology	Product	DOE Funding
Pre-pilot	Viridos	Algal biomass	Hydrotreating to SAF	SAF	\$2,000,000
	Comstock	sawmill and forestry residuals	cellulosic sugars to oils to SAF	SAF, Marine, RD	\$2,000,000
	University of Utah	Ligno-cellulosic biomass and/or sorted MSW mixed with biosolids	performance of bioliquids in the entrained flow gasifier	SAF	\$2,000,000
	University of California Riverside	Hardwood biomass	Co-Solvent Enhanced Lignocellulosic Fractionation (CELF) pretreatment and lignin fractionation operation within the hybrid catalytic biorefining (HCB)	SAF and Marine	\$2,000,000
	Captis Aire LLC	Gaseous Carbon Wood Waste (terpenes)	Terpenes feedstock to Terpenes SAF	SAF	\$2,000,000
	Research Triangle Institute	Corn Stover	Corn Stover to SAF via Catalytic Fast Pyrolysis	SAF	\$2,000,000
	Microbio	Algal Biomass	Increase algal biofuels on air derived CO2	SAF	\$3,978,199
	Algenesis	Algal Biomass	Chemical recovery of fatty acids	SAF/Polyurethane	\$4,897,974
	Global Algae Innovations	Algal Biomass	Scale up pond and production of biomass	SAF	\$3,600,000
Pilot	Lanzatech Inc (Phase 1)	Woody biomass	Woody biomass to ethanol via gasification and fermentation	SAF	\$1,640,286
	MicroBio (Phase 1)	WWT Biosolids	integrate hydrothermal liquefaction (HTL) with supercritical water oxidation (SCWO) technologies	SAF	\$579,673
Demo	Alder Fuels LLC (Phase 1)	Forest Residues	Commercial fast pyrolysis, Alder's Fast Pyrolysis oil fractionation, and hydrotreating of oils	SAF	\$2,000,000
	AVAPCO (Phase 2)	Mixed hardwood	AVAPCO's biomass fractionation technology to produce cellulosic ethanol, Petron's ethanol dehydration, and Byogy's ethylene to cellulosic SAF process	SAF	\$80,000,000

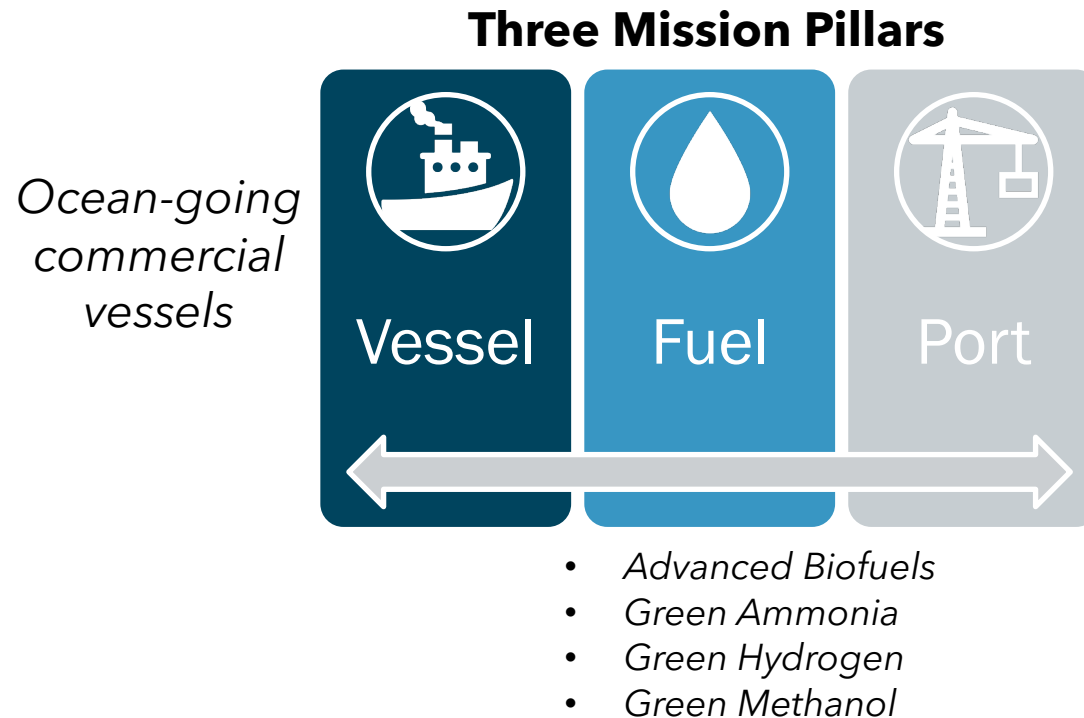
FY22 Gen-1 GHG Reduction FOA Selections

	Selectee	Feedstock(s)/Processes Input	GHG Reduction Technology	Product	Funding
Feasibility Studies	Lincolnway	Stillage & Corn stover	Natural gas off set using AD Biogas	Biogas	\$453,000
	Green Plains	1.Corn stover 2.Renewable e- 3.N/A	1.Gasification of corn stover to offset natural gas usage 2.On-site wind/solar renewable electricity production 3.Advanced crop management practices and reduced fertilizer use	N/A	\$500,000
	RenewCO2	Waste CO ₂	Catalytic electrolysis of CO ₂	Plastic Monomers	\$499,953
	Marquis	Waste CO ₂	Gas fermentation	Ethanol	\$8,327,088

Mission Innovation: Zero-emission Shipping Mission

The Goal:

- By 2030 ships capable of running on well-to-wake zero-emission fuels make up at least 5% of the global deep-sea fleet measured by fuel consumption and
- At least 200 of these ships primarily use these fuels across the main deep sea shipping routes.



Government Co-Leads



United States



Denmark



Norway

Industry Co-Leads

Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

GLOBAL
MARITIME
FORUM



Rail Decarbonization

SDI's Rail Feasibility Study – 24 Months



Biofuel Types

1. Biodiesel
2. Renewable diesel
3. Bio-oils
4. Ethanol
5. Methanol
6. RNG
7. Ammonia

Objective

Assess near-term bioenergy solutions for freight rail, their technical and economic feasibility, and their potential impact on the carbon intensity of the freight rail sector.

Outcome

Report informing the freight rail industry and fuel producers regarding these fuel options and providing a roadmap of RDD&D needs for their commercialization.

SDI Program Response to 2021 Peer Review

All projects should submit a detailed block flow diagram to understand how the project fits into the bigger picture and how the proposed improvement will have an impact

FOA applications require block flow diagram and supplementary data on process conditions, current state of technology, and sustainability metrics

Additionally, SDI participated in a FY23 BETO-wide internal portfolio analysis and updated its vision for the bigger picture in the 2023 BETO MYPP

SDI should publish a guide to conducting technoeconomic analyses, require that projects provide them during validation, and reevaluate progress during the project lifetime

FOA applications require a proforma which will be updated during subsequent milestone reviews

Proformas are vetted during the verification process. Projects no longer “work backward” from an MFSP target in order to guarantee a result

Project closeout should include routine publication of lessons learned that will be beneficial to future projects

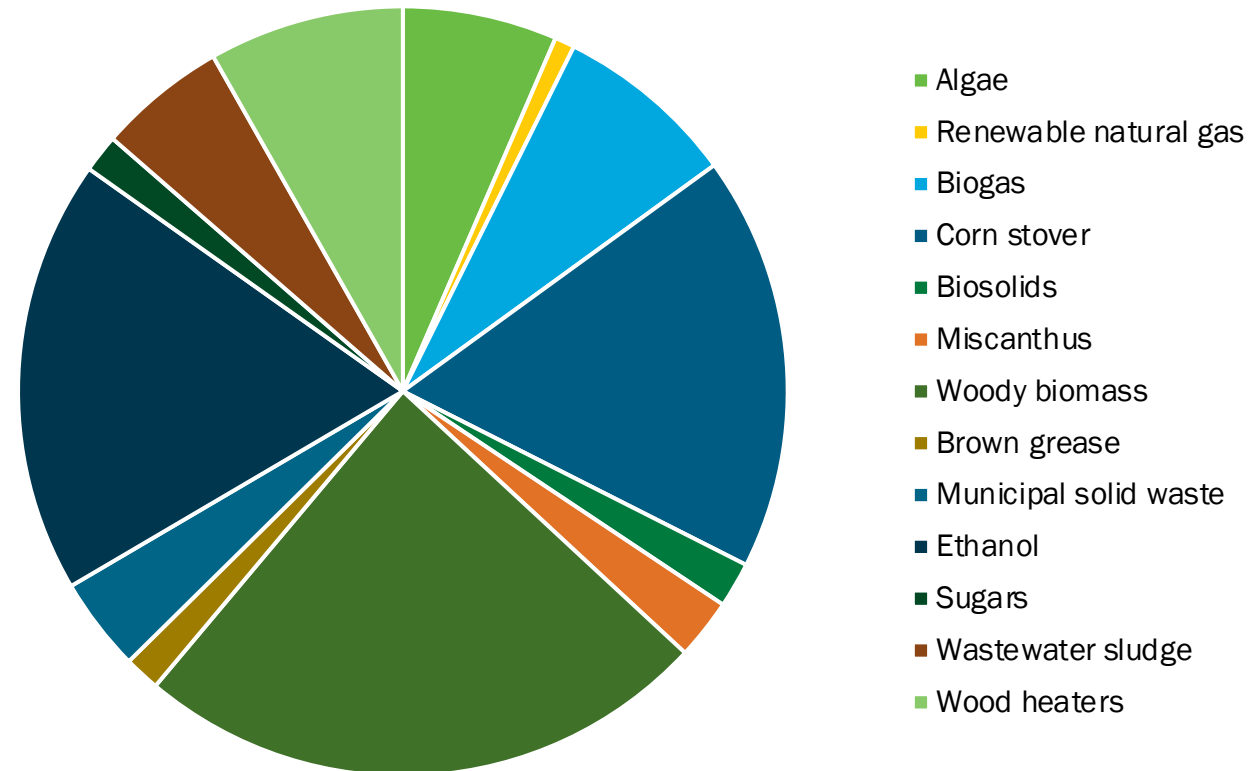
BETO requires publication of final technical reports through the Office of Scientific and Technical Information during project closeout

SDI requires its Independent Engineer to document lessons learned for projects. SDI updated its longstanding Interactive Integrated Biorefinery map

SDI 2023 Peer Review Portfolio

- **\$157 million Federal funding will be reviewed**
 - Majority of funding is technology using corn stover, woody biomass, or ethanol

Federal budget, SDI projects presenting here



SDI 2023 Peer Reviewers

Lead: Emerging and
Supporting Technologies



Dr. Gene Petersen,
Retired



Dr. Corey Leclerc,
Professor, Dean of
Engineering, New
Mexico Institute of
Mining and Technology



Dr. Marie-Odile Fortier, Assistant
Professor, University
of Nevada, Las Vegas



Dr. Rishi Shukla,
Archer Daniels
Midland Company



Dr. Amit Goyal,
Center of
Excellence,
Hydrogen/Low
Carbon Fuels, DNV

Lead: Scale-Up Portfolio



Mr. Ray Miller,
Verdecute Consulting



Mr. Joaquín Alarcón,
Catalyxx Inc



Dr. Susan van Dyk,
University of British
Columbia; SVD
Consulting



Ms. Mary Dinh,
Avangrid Renewables



Dr. Siva Sivasubramanian,
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Thank You!

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Feedstock



Algae



Conversion



Systems



Data

